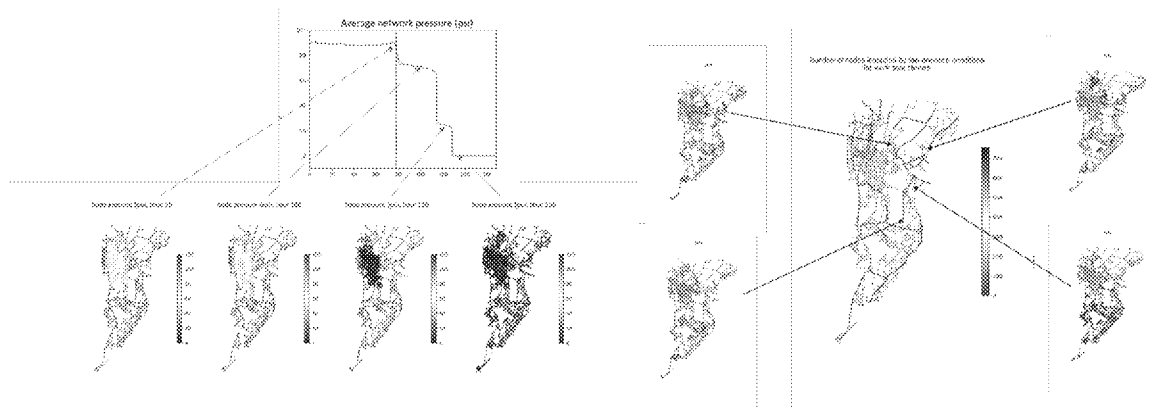# Task 1.4: WNTR Outreach FY18

The following document outlines outreach in support of water utilities, universities, industry, and government agencies interested in using WNTR. Deliverables for this task included a water utility case study, webinars, software development, and tracking use of WNTR.

Water Utility Case Study

EPA and Sandia conducted a resilience case study for the City of Poughkeepsie. The city was interested in analyzing water service in the event that the water supply was compromised. This scenario could occur due to river contamination, treatment plant failure, winter storm that freezes the water intake, or a power outage. The city was also interested in pipe criticality analysis (identifying the impact of individual pipes closures on pressure in the system) and firefighting capacity (identifying the impact of individual firefighting conditions on pressure in the system).

To define the case study, several calls were scheduled with the water utility. The water network model was reformatted into an EPANET INP file and calibrated to fit the expected population and demand in the system. The model was skeletonized to remove numerous dead-end pipes and nodes. Basic analysis, including water age and hydraulic connectivity analysis were performed to better understand the system. The hydraulic connectivity analysis identifies nodes that feed and are feed by each reservoir, tank, valves, and pump (i.e. where water is coming from, where water is going with respect to critical components). After that, the compromised water source scenario, pipe criticality, and firefighting criticality analyses were run. Sandia and EPA presented findings to the city in a series of webinars, taking in feedback and refining the analysis. A final set of slides and interactive maps were sent to the utility. We have permission from the utility to include results and graphics from this case study in other presentations. This work could be used in a future publication.

WNTR Software

WNTR is hosted on the USEPA GitHub site at https://github.com/USEPA/WNTR. This site is mirrored on the Sandia Laboratories site at https://github.com/sandialabs/WNTR to provide software testing through Travis CI and online documentation through ReadTheDocs. The software is also mirrored on code.gov.

- Python 2.7, 3.4, 3.5 and 3.6 tests are passing and available at https://travis-ci.org/sandialabs/WNTR. The software has 78% code coverage, line by line coverage stats are available at https://coveralls.io/github/sandialabs/WNTR
- Note that support for Python 2.7 and 3.4 will probably be dropped in the next year due to dependencies that will be deprecated.
- Online documentation is current and available at https://wntr.readthedocs.io
- WNTR logo was added in March 2018
- We have had 6 software releases of WNTR since the software was first made available in October 2016. Release notes are listed at https://wntr.readthedocs.io/en/latest/whatsnew.html, a summary is provided below
- The software DOI is listed at https://doi.org/10.11578/dc.20171025.1707

Version	Date	Summary
0.1	10/2016	First official release
0.1.1	2/2017	Python 3 compatible
0.1.2	5/2017	Restructured code, improved inp i/o
0.1.3	10/2017	Updates to graphics and metrics
0.1.4	2/2018	Simulation stability, updated control and rules to match EPANET, added support for multiple junction demands and FCV
0.1.5	5/2018	Deprecated use of Pandas Panels, updated metrics to clarify input
0.1.6	Master branch, to be tagged soon	Bug fixes that were identified by users
0.2?	Next release	Restructured hydraulics module

WNTR Users

The following organizations/individuals are using WNTR:

- National Renewable Energy Lab (NREL) - Clayton Barrows, Sigler Devon: working on energy/water resilience
- Los Alamos National Lab (LANL) - Donatella Pasqualini, Sara Brambilla: working on a DHS/FEMA project on infrastructure resilience
- Naval Postgraduate School - Dave Alderson, Brendan Bunn: FEMA funded hurricane resilience project for US Virgin Islands
- Las Vegas Valley Water Authority - Sri Kamojjala: working on valve isolation and planning
- University of South Florida - Noha Abdel: working with City of Tampa
- UCLA - Agam Tomar, Henry Burton: working with Napa on earthquake resilience
- Arcadis - Jim Cooper, Ben Chenevey: Earthquake resilience for Seattle
- Citilogic - Jim Uber, Sam Hatchett: general analysis, integration with EPANET
- UT Austin, Center for Infrastructure Modeling and Management – Lina Sela: integrating WNTR as an EPANET plugin
- Elad Salomons: integrating WNTR as an EPANET plugin

The following organizations/individuals have expressed interest in using WNTR:

- Alameda County Water District: Steve Peterson, Toni Lyons (District Project Engineering Manager), Ed Stevenson (Manager of Engineering and Technical Services)
- California Water: Jonathan Keck
- Napa Water: Phil Brun, Joy Eldredge, Doug DeMaster (sent a letter of support for NIST proposal)
- Portland Water Bureau: Sara Spotts
- Los Angeles Department of Water and Power (LADWP): contact through Bobby Jeffers (SNL) and Ken Hudnut (USGS)
- San Jose Water: Jake Walsh (sent a letter of support for NIST proposal) and Juneseok Lee (San Jose State University).
- Georgia Tech: Iris Tien
- North Carolina State University: Hana Chmielewski
- University of Illinois: Eun Cha, Roberto Guidotti, Omar Elabd working with NIST, In-CORE
- National Institute of Standards and Technology, Community Resilience Group
- DOE Office of Electricity Delivery and Energy Reliability, Infrastructure Security and Energy Restoration: Jeffrey Baumgartner
- Universidad de los Andes in Colombia: Juan Saldarriaga
- Electric Infrastructure Security (EIS): John Organek
- Leidos: Rakesh Bahadur
- Xylem: Amin Rasekh
- Global Quality Corp: Sudhir Kshirsagar
- Fort Bragg
- Fort Campbell

Individuals who are watching (23), stared (49), or forked (42) WNTR include:

User name	Name	Organization
Personal Security Detail / Ex. 6	Abhiram	kLabUM open-storm, Ann Arbor MI, Open source sensors, hardware, algorithms for water systems
	Andrew Knapp	Software Engineering at Tableau Software, Seattle
	Agam Tomar	PhD student, UCLA
	Ahmed Jabrane	Mines ParisTech
	Alex Harbord	Engineering undergrad, Oxford University
	Amin Rasekh	Xylem
	Andrew Yuen	EPA
		Nuclear engineer, software developer
		Senior Computer Engineering Students, Cairo, Egypt
	Blaise Pabon	Software engineer, Mountain View, CA
	Bret Carpenter	Nautic Scepter, Birmingham MI
	Jeff Stubler	Milwaukee, WI
	Carl Laird	Sandia
	Cristian Cazan	
	Brad Cooper	Eastern Research Group, Inc., Software developer, member of EPA GitHub org
	Cat Trombley	code.gov
	Daniel Hart	EPA
	David Hart	Sandia
	Deepak Vengatesh	
	Denis Akhiyarov	Software Developer, Wood and NAU, Texas
		EPANET developer?
	Dylan Moriarty	Sandia
	DrewKeefer	
	Theodore Cleveland	Texas Tech University, NCIMM
	E Abraham	EPANET developer?
	Ehsan Madadi	UT Austin, NCIMM
	Demetrios Eliades	KIOS, Cyprus
	Flavio Wächter	Switzerland
	Ivo Silvestre	Center for Marine and Environmental Research (CIMA), GIS Coordinator, Faro, Portugal
	Jim Uber	CitiLogics
	Justin Geiman	Fire & Risk Alliance, Maryland

	Jorge Pesantez	North Carolina State Univ
	Joerg Rings	Data Scientist, Chicago (converted WNTR to Python 3)
	Juan Carlos Castilla-Rho	University of Wollongong, CSIRO Land & Water, Australia
	Kate Klise	Sandia
	Kevin Mader	Cofounder of 4Quant (big data analytics) and Lecturer at ETH Zurich, Switzerland
		EPANET developer?
	Daniel Bishop	Product Manager at automotiveMastermind, San Francisco. Big Data Behavioral Analytic
	Marios Kyriakou	KIOS, Cyprus
	Masud Hassan	UT Austin?
	Oleg Merzlyakov?	Minsk
		seems to have forked everything from EPA Github
	Michael Bynum	Sandia
	Michael Tryby	EPA
		Kansas City, MO
	Michael Rustler	Kompetenzzentrum Wasser Berlin gGmbH KWB-R (Berlin Centre for Applied Water Research and Knowledge Transfer)
	Omar Elabd	Univ of Illinois, NIST-CORE
	Gerald Chen	GEOINTX, China
	Praveen Venkateswaran	Computer science, University of California Irvine
	Todor Stoychev	Software engineer, London, UK
	Regan Murray	EPA
	Robert Janke	EPA
	Ryan Kuhl	Kuhl Technologies & Consulting, LLC, Ruby and Python Software Engineer at TrueCar, Santa Monica
	Rin Arakaki	Tokyo, Japan
	Ry Whittington	Python developer and data scientist, Caterpillar, Inc
	Sam Hatchett	CitiLogics
		Sandia
	Santiago Rodriguez	Purdue University
		Water-energy research
	Joshua Santillo	Georgia Tech
	Sidney Schaberle Goveia	Geosaber, Brazil
	Tathagata Dasgupta	HERE technologies Chicago, mapping applications

Personal Security Detail / Ex. 6	Tyler Bradley	Environmental Engineer with the Philadelphia Water Department
	Terra Haxton	EPA
		Engineer
	Jonathan Burkhardt	EPA
	Joel Khan	Github developer program member?
	Hyoungmin Woo	EPA
	Yusuf Simonson	CTO of the Muse, previous software developer at Microsoft, IBM and Associate Product Manager at Google
		EPANET developer?

Use Statistics

Use statistics are gathered in several ways. We use Google analytics to track visitors to the online documentation at https://wntr.readthedocs.io. The site receives approximately 200 visitors per month from all over the world (30% from the US). 24% of visitors return to the site. Top 10 page views are listed below:

Page	Views
/	1128
/Installation	865
/Overview	861
/API documentation	839
/Hydraulic simulation	819
/Water network model	799
/Getting started	705
/Simulation results	552
/Water network controls	539
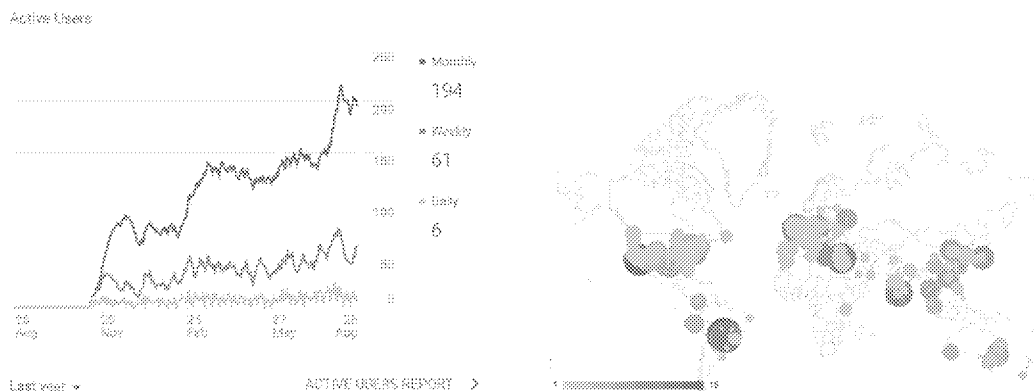
We also track download statistsics from PyPi. As of May 2018, WNTR has been downloaded over 7000 times from PyPi. These are tagged (released) versions of WNTR that users download using 'pip install wntr'.

On GitHub, the software has been cloned 180 times and the website has had nearly 4000 visitors. There was a large increase in visitors after the software was mirrored at code.gov in November 2016.
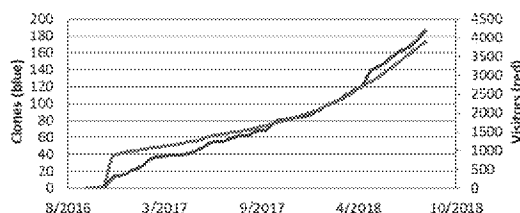
Webinars and Classes

This year, we hosted several webinars and classes to help people get started with WNTR. The slides and content could be refined to create a general purpose webinar or class.

- In April, we gave a short demo of WNTR to researchers at NREL, interested in studying energy-water resilience.
- In April, we also gave a webinar to researchers at the Naval Postgraduate School, interested in energy-water resilience related to hurricanes in USVI. This group also works with Sandia on operations research using Pyomo.
- In May, we gave a webinar to researchers at LANL, who are working on a FEMA project on water infrastructure resilience.
- In May, we helped teach a class on open source software development, related to EPANET at the EWRI conference

Publications and Presentations

Three papers have been published on WNTR. These papers are listed on the GitHub site and in the online documentation.

- Klise, K.A., Murray, R., Haxton, T. (2018). An overview of the Water Network Tool for Resilience (WNTR), In Proceedings of the 1st International WDSA/CCWI Joint Conference, Kingston, Ontario, Canada, July 23-25, 075, 8p.
- Klise, K.A., Bynum, M., Moriarty, D., Murray, R. (2017). A software framework for assessing the resilience of drinking water systems to disasters with an example earthquake case study, Environmental Modelling and Software, 95, 420-431, doi: 10.1016/j.envsoft.2017.06.022
- Klise, K.A., Hart, D.B., Moriarty, D., Bynum, M., Murray, R., Burkhardt, J., Haxton, T. (2017). Water Network Tool for Resilience (WNTR) User Manual, U.S. Environmental Protection Agency Technical Report, EPA/600/R-17/264, 47p.

The team presented at several conferences, including

- CoDA - Conference on Data Analysis
- EWRI
- ACE
- UNM Resilience conference
- WDSA/CCWI
- The team also participated in the EPANET Visioning Summit

Factsheet

A factsheet was developed to promote WNTR. The factsheet has gone through Sandia R&A and (I believe) is also available on an EPA template. Additional factsheets could be developed as needed. The factsheet could be included on the GitHub page and/or online documentation.

Email Announcements

Sandia developed an email template and mailing list with 80 people that can be used to send periodic announcements about the software. We can use the Sandia's GovDelivery service to manage the emails. We are waiting on EPA approval before sending this out. This is an easy way to remind people that WNTR is an active project. People could sign up to receive announcements through the GitHub and ReadTheDocs site. They should also be able to unsubscribe through the email.

You are receiving this email because of your interest in the Water Network Tool for Resilience (WNTR) software project, if you would like to be removed from this email list, unsubscribe here (link).

Announcing WNTR Version 0.1.5

WNTR 0.1.5 is now available. Version 0.1.5 includes updates to keep WNTR compatible with Pandas and additional updates to resilience metrics. See http://wntr.readthedocs.io/en/latest/whatsnew.html for release notes.

The Water Network Tool for Resilience (WNTR) is an open source Python package designed to simulate and analyze resilience of water distribution networks. The United States Environmental Protection Agency, in partnership with Sandia National Laboratories, developed WNTR to integrate critical aspects of resilience modeling for water distribution networks into a single software framework.

WNTR
Water Network Tool for Resilience

WNTR is hosted on the US EPA GitHub site at http://github.com/usepa/wntr.
Online documentation is available at http://wntr.readthedocs.io.

The software includes capability to:
- Generate water network models or load in EPANET INP model files
- Modify network structure and operations
- Assign fragility and survival curves to network components
- Model disruptive events such as power outages, earthquakes, fires, pipe breaks, and contamination incidents
- Model response and repair strategies
- Simulate hydraulics (demand-driven or pressure dependent demand) and water quality
- Evaluate resilience using a wide range of metrics
- Analyze results and generate graphics

WNTR can be used to estimate infrastructure damage, evaluate preparedness strategies, prioritize response actions, and identify worse case scenarios and best practices for maintenance and operations. WNTR integrates several open source Python packages commonly used by the data science community, including Numpy, Scipy, Pandas, NetworkX, Matplotlib, and Plotly. Combining these tools with hydraulic and water quality analysis facilitates broad flexibility to build custom analysis.

WNTR can be installed using the pip Python package management system, by downloading a zip file from the GitHub website, or by cloning the git repository. Installation instructions are available online.

For more information or to conduct a case study, contact:
    Katherine Klise, kaklise@sandia.gov
    Regan Murray, Murray.Regan@epa.gov

Citations and Recognition

WNTR have been cited several times, including:

- Taormina, R., S. Galelli, and H. C. Douglas. "Modeling Cyber-Physical Attacks on Water Networks with epanetCPA." WDSA/CCWI Joint Conference Proceedings. Vol. 1. 2018.
- Zakrzewski, P., Rafal Brodziak, and Jedrzej Bylka. "Battle of Post-Disaster Response and Restauration (BPDRR)." WDSA/CCWI Joint Conference Proceedings. Vol. 1. 2018
- Han, Qing, et al. "Enabling State Estimation for Fault Identification in Water Distribution Systems under Large Disasters.", ics.uci.edu
- Gibert, Karina, et al. "Environmental Data Science." Environmental Modelling & Software 106 (2018): 4-12.
- Vrachimis, Stelios G., and Marios S. Kyriakou. "LeakDB: A benchmark dataset for leakage diagnosis in water distribution networks." WDSA/CCWI Joint Conference Proceedings. Vol. 1. 2018.
- Romano, Emanuele, et al. "A Stakeholder Oriented Modelling Framework for the Early Detection of Shortage in Water Supply Systems." Water (20734441) 10.6 (2018).
- Meng, et al. "Topological attributes of network resilience: A study in water distribution systems", Water Research, 143, 376-386, 2018

WNTR has also been featured in the following presentations, reports, and websites:

- Alvand Salehi, the Senior Technology Advisor at the White House, gave a talk about government open source software at South by Southwest and featured WNTR as a success story, March 9, 2018
- WNTR is a featured software project on code.gov (see below).
- Katy Huff, professor at University of Illinois, featured WNTR in a keynote talk at PyCon 2017
- WNTR was included in the AWWA Webinar "Water Sector Black Sky Resilience", October 18, 2017WNTR was highlighted in the Water Sector Black Sky Playbook, written by the Electric Infrastructure Security Council, John Organek